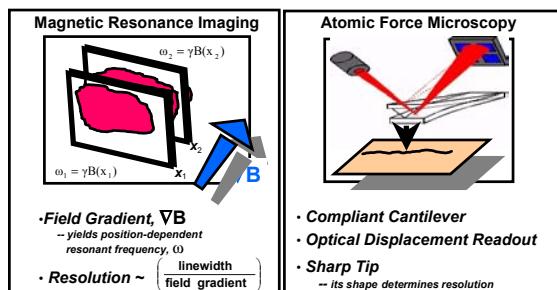


Magnetic Resonance Force Microscopy (MRFM)

R. Movshovich (LANL), D. Pelekhanov, and P. C. Hammel (OSU)

Magnetic Resonance Force Microscope Underlying principles



Force Detection of Magnetic Resonance

INGREDIENTS:

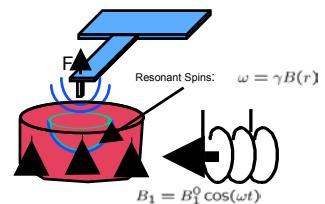
sensitive force detector

- compliant mechanical element
- displacement readout

miniature magnet

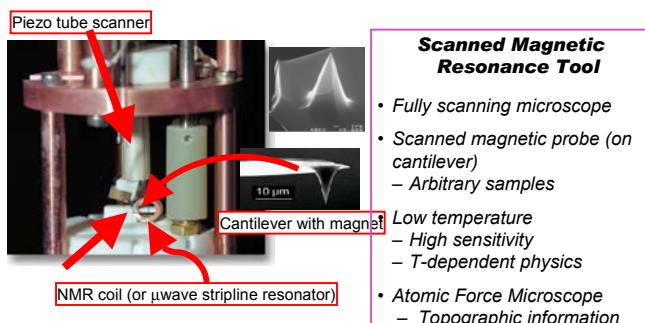
generates field gradient:

- provides coupling to spins
- defines magnetic resonance imaging volume
- $\omega(r) = \gamma B(r)$

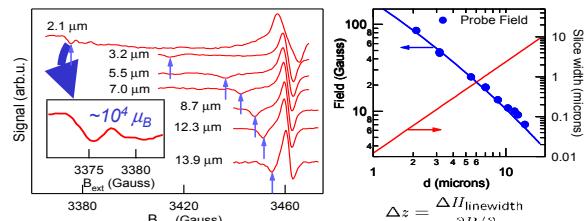


J. A. Sidles, Appl. Phys. Lett. 58, 2854 (1991)

Magnet on Cantilever Scanned MRFM Instrument

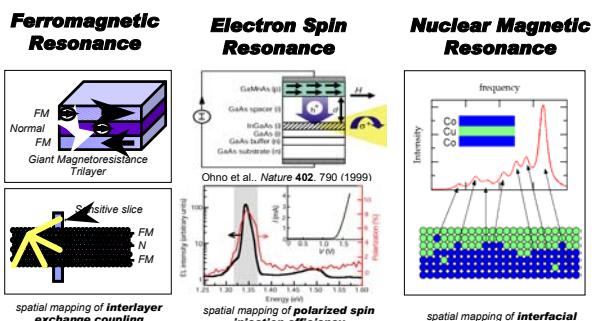


High Sensitivity Electron Spin Resonance



- Observation of sensitive slice entering sample
- Direct measurement of probe tip magnetic field
 - field gradient $\nabla B = 5150 \text{ T/m}$ for probe 2.1 μm above sample
- Measurement of slice width (spatial resolution)
 - slice width 30-50 nm for probe 2.1 μm above sample

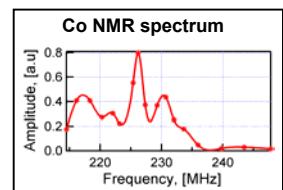
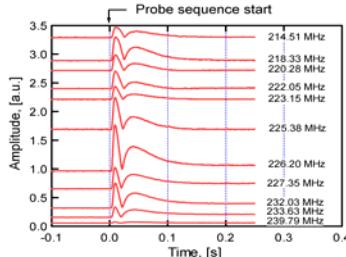
Magnetic Resonance Studies Buried Magnetic Interfaces



NMRFM Mode of Operation: Co Thin Film (Dots)

Time dependence of the cantilever vibration amplitude

Conditions of signal acquisition:
 $T = 4 \text{ K}$, $B_{\text{appl}} = 0.5 \text{ T}$, \perp film plane
Probe-sample distance $1 \mu\text{m}$



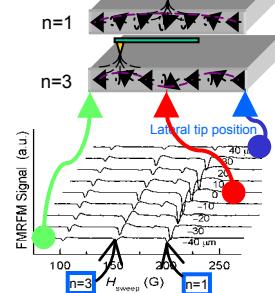
Summary



FMR Imaging Lateral Scanning in Patterned YIG Samples

- Lateral scan: local **detection** of magnetization associated with various magnetostatic modes
- Suppression of all modes toward edge of sample
- Non-monotonic dependence of $n=3$ mode

M. Midzor, P. Wigen, M.L. Roukes D.
Pelekhanov and P.C. Hammel



New Capabilities

- non-destructive 3D sub-surface imaging
- general magnetic resonance instrument
- imaging with chemical specificity
- ultimate spatial resolution: **atomic**
- ultimate sensitivity: **single spin**